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EFFECTS OF TRIMMING AND PACKAGING METHODS ON KEEPING QUALITY OF

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UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Marketing Service Market Quality Research Division

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Washington, D. C. May 1960

EFFECTS OF TRIMMING AND PACKAGING METHODS ON KEEPING QUALITY OF LETTUCE

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SUMMARY

Western lettuce, trimmed and packaged by various methods immediately after harvest, was shipped east by rail in regular Navy shipments, then stored at 33° and 38° F., to determine the effectiveness of different methods of trimming and packaging in prolonging storage life.

Unwrapped and parchment-wrapped lettuce cooled somewhat faster by the vacuum process than lettuce in polyethylene-lined crates or in individual polyethylene bags. The average transit temperatures also were slightly lower in the unwrapped and parchment-wrapped heads. Arrival temperatures, however, were approximately the same in all packages after a 9- or 10-day transit period.

Lettuce in polyethylene-lined crates and in individual polyethylene bags lost far less weight and remained much more crisp during transit and storage than unwrapped or parchment-wrapped lettuce, which was badly wilted after only 3 weeks in storage. Weight losses in all packages were generally greater at 38° than at 33° F., particularly after 5- and 7-week storage periods.

The smallest trimming losses at every inspection and at both storage temperatures occurred in polyethylene-bagged lettuce. The greatest losses occurred in unlined crates containing commercially trimmed heads. The amount of trimming before packaging directly influenced the amount of trimming subsequently required. The data obtained at 38° F., for example, show that commercially trimmed heads, with seven or more wrapper leaves, required about 5 percent more trimming after storage than regularly trimmed heads which had only five or six wrapper leaves. Specially trimmed heads, with only three or four wrapper leaves, required the least trimming after storage.

Lettuce decayed much more rapidly at 38° F. than at 33°, and more rapidly in polyethylene-lined and unlined crates than in individual polyethylene bags. At almost every inspection, more lettuce remained edible in polyethylene bags than in any other package. The least amount of edible lettuce was found in unlined crates of commercially trimmed heads. About equal amounts remained edible in unlined crates of parchment-wrapped heads and in polyethylene-lined crates of unwrapped heads. The average amount of edible lettuce in all packages was greater after 7 weeks at 33° than after 5 weeks at 38°. An average of 3 pounds more lettuce per crate remained edible after 3 to 7 weeks' storage at 33° when the heads were specially trimmed and packed in individual polyethylene bags than when they were packed by the conventional Navy method (heads regularly trimmed and parchment-wrapped).

Russet spotting, a serious physiological disease of lettuce, was much more severe in lettuce stored at 38° F. than in lettuce stored at 33°. It was also much more severe in test 4, initiated in May, than in earlier tests initiated in December, January, and March.

Trimming the lettuce before packaging markedly reduced the weight and shipping space required. Crates of commercially trimmed heads averaged 48 pounds when shipped;

crates of regularly trimmed heads with five or six wrapper leaves averaged 45.5 pounds; and crates of specially trimmed heads with three or four wrapper leaves averaged only 40 pounds.

INTRODUCTION

In an effort to prolong the storage life of lettuce in the U. S. Navy supply system, various methods of trimming, storing, and packaging have previously been compared in laboratory tests. Lettuce for these earlier tests was purchased in commercial containers at wholesale markets in Washington, D. C.; therefore, any special packaging in these tests was applied after a transit period of undetermined duration and temperature exposure.

New tests were initiated in 1958, in cooperation with the U. S. Navy, to further evaluate some of the more promising methods of trimming and packaging lettuce under actual harvesting and shipping conditions of Navy purchase. Lettuce for these tests was trimmed and packaged in the field immediately after harvest rather than after a transit period. The type of container and method of shipment were identical to those regularly used by the Navy. All of the test packages were included in regular rail shipments consigned to the Navy at Norfolk, Va.

Materials and Methods

Four tests were initiated during the period Dec. 6, 1958, to May 29, 1959. The test shipments originated in the Yuma and Salt River districts of Arizona and the Imperial and Salinas-Watsonville districts of California.

Six methods of trimming and packaging the lettuce were used in the tests:

(1) Heads regularly trimmed, individually wrapped in parchment, and packed in unlined crates.

(2) Heads specially trimmed, individually wrapped in parchment, and packed in unlined crates.

(3) Heads regularly trimmed, unwrapped, and packed in polyethylene-lined crates.

(4) Heads specially trimmed, unwrapped, and packed in polyethylene-lined crates.

(5) Heads specially trimmed, placed in individual polyethylene bags, and packed in unlined crates.

(6) Heads commercially trimmed, unwrapped, and packed in unlined crates. (This method not included in first test).

Regularly trimmed heads, with five or six wrapper leaves, were similar to those being received in typical Navy export shipments. Specially trimmed heads were more closely trimmed to only three or four wrapper leaves. Commercially trimmed heads, with seven or more wrapper leaves, were similar to those received in wholesale markets. The parchment wraps, 20 inches square, were made of approximately 40-pound stock. The polyethylene crate liners, 36 inches wide and approximately 38 inches long, were formed from 1-1/2-mil stock. Polyethylene bags were 21 inches long, 8 inches wide, with a 3-inch gusset, and were formed from 1-1/4-mil stock. Wirebound crates, regularly used by the U. S. Navy for export shipments, were employed in the tests. Each crate held 24 heads of lettuce and measured 15 inches by 18 inches by 24 inches. The lettuce used in each test constituted part of a carlot purchase by the Navy for export.

Trimming and packaging of the lettuce was done in the field by the contractor's regular field crew members under the supervision of U. S. Department of Agriculture and Military Subsistence Supply Center personnel. Twelve crates were prepared by each method employed in the test. Recording thermometers were placed in two crates packed by each method. After packing, the test crates of lettuce were weighed and vacuum cooled. They were then placed in a refrigerated car as a part of a Navy shipment to Norfolk, Va. On arrival, the load was inspected by personnel of the U. S. Department of Agriculture. All lettuce arrived in good condition at Norfolk except the last lot (test 4). Eleven percent of the inspected heads in this lot were infected with bacterial soft rot and the entire carlot was rejected by the Navy. After the test packages of each lot were recovered at Norfolk they were taken to the Plant Industry Station of the Department of Agriculture at Beltsville, Md., where the recording thermometers were removed and the packages reweighed and placed in storage. Six crates packed by each method were stored at 33° and six at 38° F.

Inspections of the lettuce were made after 3, 5, and 7 weeks. Two crates packed by each method from each storage temperature were inspected each time. The crates were reweighed to determine the weight loss. Each head was then examined for bruising or crushing, decay, and russet spotting. The inedible portions were removed and the percentage remaining edible in each crate was determined.

All percentages given in this report are based only on the number of heads or the weight of lettuce at the time of packing. The weight of containers and packing materials are not included.

Results

Temperature: Although harvested over a period of 6 months at four locations, the average temperatures in the various test packages prior to vacuum cooling were remarkably consistent, varying only from 59° to 61° F. Arrival temperatures at Norfolk averaged 39° for all tests. The highest temperature recorded on arrival was 43° and the lowest was 34°.

Cooling during the vacuum process was slightly faster in unlined crates than in polyethylene-lined crates, the decrease in temperature averaging 14° in the lined crates and 20° in the unlined crates (fig. 1). Cooling during transit, averaging 4°, was fairly uniform in all crates and the temperature differences that existed, after vacuum cooling, in lettuce in polyethylene-lined and unlined crates were generally maintained during most of the transit period. The temperatures also were generally higher in crates of polyethylene-bagged lettuce than in crates of unbagged lettuce. The difference in the cooling rate was undoubtedly due to a restriction by the liners and bags of evaporation from the lettuce heads, which reduced the efficiency of the vacuum cooling process. A slightly longer period under vacuum might be desirable when lettuce is being cooled in liners or bags. Heads wrapped in parchment cooled almost as rapidly as unwrapped heads, and transit temperatures of the wrapped heads were among the lowest recorded in the tests.

Weight loss: Lettuce packed in unlined crates without bagging or wrapping lost more weight during transit and storage than lettuce packed by any other method. The average loss in this package for all tests was 7.4 percent of the original weight as compared to 6.2 percent in packages of parchment-wrapped lettuce. In contrast, the loss in polyethylene liners and bags averaged 2.5 percent or less (table 1). Because of this difference in weight loss, parchment-wrapped and unwrapped lettuce in unlined crates was badly wilted when it was removed from storage, while lettuce stored in polyethylene liners and bags usually remained fresh and crisp. Polyethylene bags afforded the greatest protection against loss of weight of any package tested, due principally to their close fit around the heads and the low permeability of the film itself to the passage of water vapor.

The average weight loss in all packages increased with the length of the storage period, but the principal loss usually occurred during the cooling and transit period and the first 3 weeks in storage. Parchment-wrapped heads, for instance, had lost slightly more

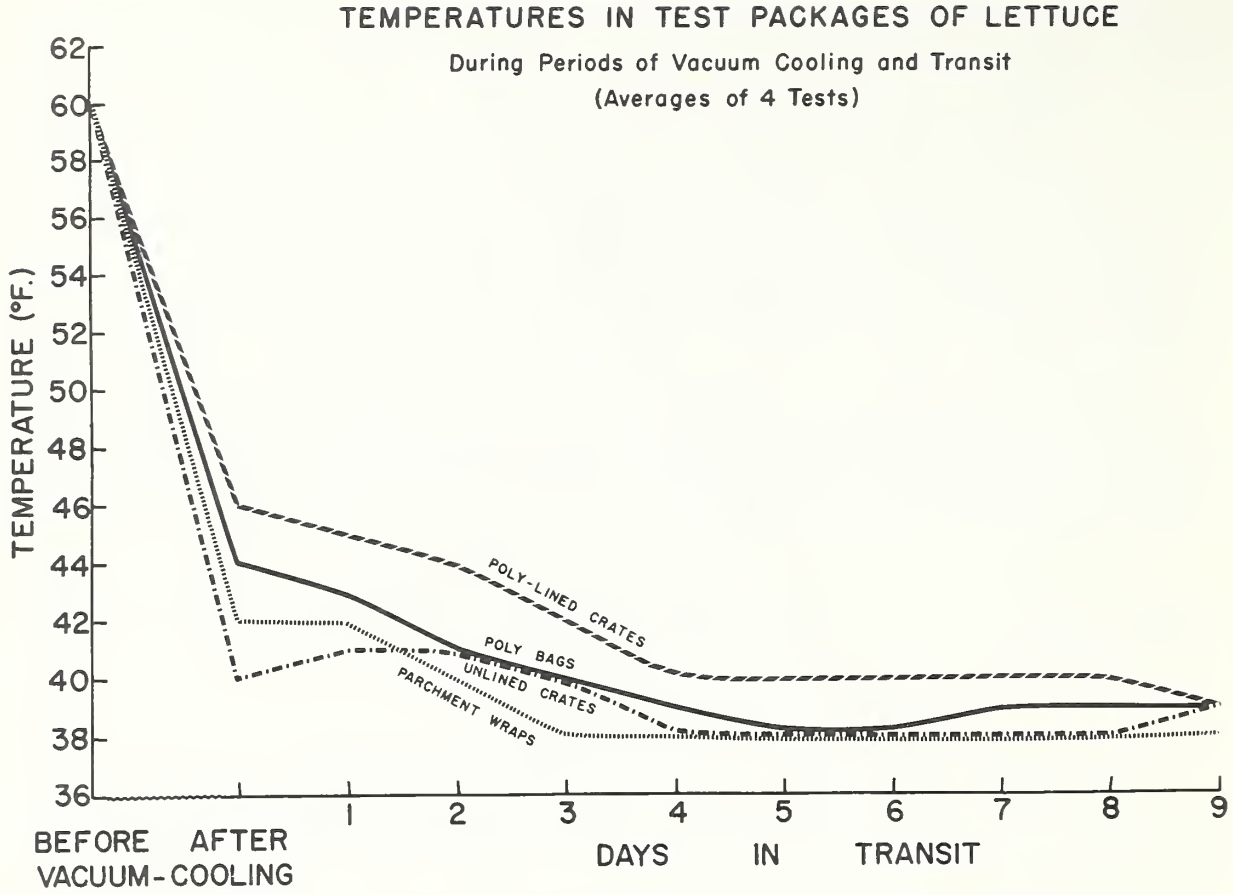

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Figure 1.

TABLE 1.--Weight loss of lettuce during transit and storage at 33° or 38° F. in various types of containers

Trimming and packaging treatment	Percentage weight loss at							
	33° F.				38° F.			
	After storage for			Av.	After storage for			Av.
	3 wks	5 wks	7 wks		3 wks	5 wks	7 wks	
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Regularly trimmed, parchment-wrapped heads in unlined crates[1]............	5.0	6.0	7.0	6.0	4.7	6.2	7.8	6.2
Specially trimmed, parchment-wrapped heads in unlined crates[1]............	4.8	6.2	7.1	6.0	4.6	6.6	8.1	6.4
Regularly trimmed heads in polyethylene-lined crates..................	1.7	1.0	1.9	1.5	1.4	2.4	9.7	2.5
Specially trimmed heads in polyethylene-lined crates..................	1.6	1.2	1.8	1.5	1.4	1.6	2.9	2.0
Specially trimmed, polyethylene-bagged heads in unlined crates..............	1.3	1.5	1.4	1.4	1.0	1.1	1.9	1.3
Commercially trimmed heads in unlined crates[1]...........................	6.0	6.5	7.4	6.6	5.7	7.3	11.3	8.1

---

[1] Regularly trimmed, with 5-6 wrapper leaves remaining; specially trimmed, 3-4 wrapper leaves remaining; commercially trimmed, 7 or more wrapper leaves remaining.

than 7 percent of their original weight after 7 weeks' storage at 33° F. About two-thirds of this loss, however, occurred during the cooling and transit periods and the first 3 weeks in storage, and was sufficient to produce severe wilting.

Weight losses were about equal at 33° and 38° F. after 3 weeks in storage. After longer periods, the loss was generally greater at 38° than at 33°.

Trimming loss: Trimming losses in the various test packages due to decay, breakage, and discoloration were considerably less at 33° than at 38° F. The average loss in all packages for 3 to 7 weeks of storage was 35.5 percent at 33° as compared to 51.8 percent at 38° (table 2). In most instances, decay was the primary cause of the trimming loss, but breakage also was important, particularly when commercially trimmed heads were stored. More breakage occurred in polyethylene liners and bags than in parchment wraps due to the greater crispness of the lettuce in the plastic containers. Russet spotting, a physiological disease, was the cause of a considerable amount of trimming, especially of lettuce stored at 38°.

The greatest trimming losses occurred in commercially trimmed heads in unlined crates. The seven or more wrapper leaves on these heads were usually broken, dirty, and highly susceptible to decay. In addition, since there was no barrier between the heads, decay spread rapidly from head to head. Specially trimmed heads, with three or four wrapper leaves, stored in polyethylene liners or in parchment wraps, generally required less trimming after storage than similarly packaged, regularly trimmed heads, with five or six wrapper leaves. Both required less trimming after storage than the heads stored with all wrapper leaves intact.

Average trimming losses of both regularly and specially trimmed heads were slightly greater in polyethylene liners than in parchment wraps. This was due apparently to the lack of any protection between heads in the liners, which allowed the decay to spread more rapidly, and to the greater amount of breakage in the liners.

The smallest trimming loss occurred in lettuce packed in individual polyethylene bags, averaging approximately 11 percent less at 33° and 38° F. than the average loss in all other packages combined. The use of individual bags largely prevented the spread of decay from head to head within the crate and thus reduced the amount of trimming. Trimming losses due to wilting alone were negligible in bags.

Decayed heads: At each inspection, the heads in each package showing decay were counted. During each storage period, a much greater number of heads decayed at 38° than at 33° F. (table 3). More heads decayed in 5 weeks at 38° than in 7 weeks at 33°. This again demonstrates the advantage of storing lettuce at temperatures as near 32° as possible. The average number of decayed heads for all inspections was less in polyethylene bags than in the other packages. The average number of regularly and specially trimmed heads decayed at all inspections was slightly greater in polyethylene-lined crates than in parchment wraps.

Weight of edible lettuce: The greatest weight of edible lettuce at almost every inspection was found in crates of polyethylene-bagged heads (table 4). The least edible lettuce was found in crates of commercially trimmed heads. Lettuce in all packages stored at 33° F. kept better than lettuce in similar packages stored at 38°. More of the original lettuce remained edible after 5 weeks at 33° than after 3 weeks at 38°. Similarly, more lettuce remained edible after 7 weeks at 33° than after 5 weeks at 38°.

An average of 3 pounds more lettuce remained edible after 3 to 7 weeks' storage at 33° F. when the heads were specially trimmed and packed in individual polyethylene bags, rather than packed by the conventional Navy method (heads regularly trimmed and parchment-wrapped). The difference at 38° was 4 pounds.

Russet spotting: This physiological disease is characterized by numerous small, brown or red-brown lesions, particularly on the midribs of affected leaves. The lesions, although not affecting the flavor of the lettuce, make the entire head unattractive. The

TABLE 2.--Trimming loss of variously packaged heads of lettuce after transit and storage at 33° or 38° F. for 3, 5, and 7 weeks

Trimming and packaging treatment	Percentage trimming loss at							
	33° F.				38° F.			
	After storage for			Av.	After storage for			Av.
	3 wks	5 wks	7 wks		3 wks	5 wks	7 wks	
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Regularly trimmed, parchment-wrapped heads in unlined crates[1]............	29.6	37.6	44.8	37.3	48.0	56.3	61.1	55.1
Specially trimmed, parchment-wrapped heads in unlined crates[1]............	23.4	28.6	38.9	30.3	39.2	47.6	57.4	48.1
Regularly trimmed heads in polyethylene-lined crates..................	29.2	39.7	47.2	38.7	44.6	56.4	65.2	55.4
Specially trimmed heads in polyethylene-lined crates..................	28.6	37.3	47.2	37.7	38.5	51.2	58.8	49.5
Specially trimmed, polyethylene-bagged heads in unlined crates.............	17.9	24.4	31.2	24.5	29.7	46.6	53.8	43.4
Commercially trimmed heads in unlined crates[1]............................	35.8	44.7	53.5	44.7	54.1	59.7	65.1	59.6
Average all treatments............				35.5				51.8

[1] Regularly trimmed, with 5-6 wrapper leaves remaining; specially trimmed, 3-4 wrapper leaves remaining; commercially trimmed, 7 or more wrapper leaves remaining.

TABLE 3.--Average number of decayed heads of lettuce in various test packages after 3, 5, and 7 weeks at 33° or 38° F

Trimming and packaging treatment	Number of decayed heads at							
	33° F.				38° F.			
	After storage for			Av.	After storage for			Av.
	3 wks	5 wks	7 wks		3 wks	5 wks	7 wks	
	No.	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*
Regularly trimmed, parchment-wrapped heads in unlined crates[1]............	1	10	19	10	10	23	24	19
Specially trimmed, parchment-wrapped heads in unlined crates[1]............	2	7	17	9	5	20	23	16
Regularly trimmed heads in polyethylene-lined crates..................	3	11	18	11	13	23	24	20
Specially trimmed heads in polyethylene-lined crates..................	9	16	20	15	10	17	23	17
Specially trimmed, polyethylene-bagged heads in unlined crates.............	4	7	14	8	5	17	22	15
Commercially trimmed heads in unlined crates[1]............................	4	16	19	13	7	24	24	22

[1] Regularly trimmed, with 5-6 wrapper leaves remaining; specially trimmed, 3-4 wrapper leaves remaining; commercially trimmed, 7 or more wrapper leaves remaining.

TABLE 4.--Lettuce remaining edible in various test packages after transit and 3, 5, an
7 weeks at 33° or 38° F

Trimming and packaging treatment	Pounds of lettuce remaining edible after storage at							
	33° F.				38° F.			
	After storage for			Av.	After storage for			Av.
	3 wks	5 wks	7 wks		3 wks	5 wks	7 wks	
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Regularly trimmed, parchment-wrapped heads in unlined crates[1]...........	25	22	19	22	18	15	12	15
Specially trimmed, parchment-wrapped heads in unlined crates[1]...........	25	22	19	22	19	15	12	15
Regularly trimmed heads in polyethylene-lined crates.................	28	23	20	24	21	16	11	16
Specially trimmed heads in polyethylene-lined crates.................	23	21	17	20	21	15	13	16
Specially trimmed, polyethylene-bagged heads in unlined crates............	27	25	23	25	24	18	15	19
Commercially trimmed heads in unlined crates[1]...........................	23	19	15	19	16	13	9	13
Average all treatments.............	25	22	19		20	15	12	

[1] Regularly trimmed, with 5-6 wrapper leaves remaining; specially trimmed, 3-4 wrapper leaves remaining; commercially trimmed, 7 or more wrapper leaves remaining.

symptoms of the disease are sometimes not observed in lettuce after short transit or storage periods. They do, however, become increasingly apparent with longer storage periods, particularly when the lettuce is held at temperatures favorable for their development. In the current tests, russet spotting was observed at the time of arrival only in lettuce of test 4 (fig. 2).

In general, lettuce stored at 38° F. was more severely affected by the disease than lettuce stored at 33° (table 5 and fig. 3). After 3 weeks, for example, an average of 3.7 leaves per head were affected by the disease at 33°, compared to 7.5 leaves at 38°. A similar difference was observed also after 5 weeks. Because of the decayed condition of some of the lettuce after 7 weeks, russet spotting counts could not be obtained for all heads. In the counts that were made, the difference between the number of affected leaves at the two temperatures was similar to that obtained at the earlier inspections.

Russet spotting was much less severe in tests initiated in December, January, and March than in the test initiated in May. No actual counts were made of affected leaves in test 1, but the lettuce was observed to be very similar to that in tests 2 and 3 in regard to russet spotting. After 3 weeks at 33° F., spotting was observed on an average of less than 1 leaf per head in lettuce from tests 2 and 3, but was observed on an average of over 10 leaves per head in lettuce from test 4. The cause of this difference is not known, but it has been previously observed that lettuce harvested during the late spring and summer in the western lettuce-producing areas is more subject to russet spotting than that harvested in other seasons.

No consistent difference was observed in the amount of russet spotting in the various packages, although it was usually least severe in polyethylene bags. The small change in the atmosphere within these bags (CO_2-2.0%; O_2-20.0%) may have had some effect. It was clear in these tests, however, that the storage temperature exerted the greatest effect in controlling the spread of the disease.

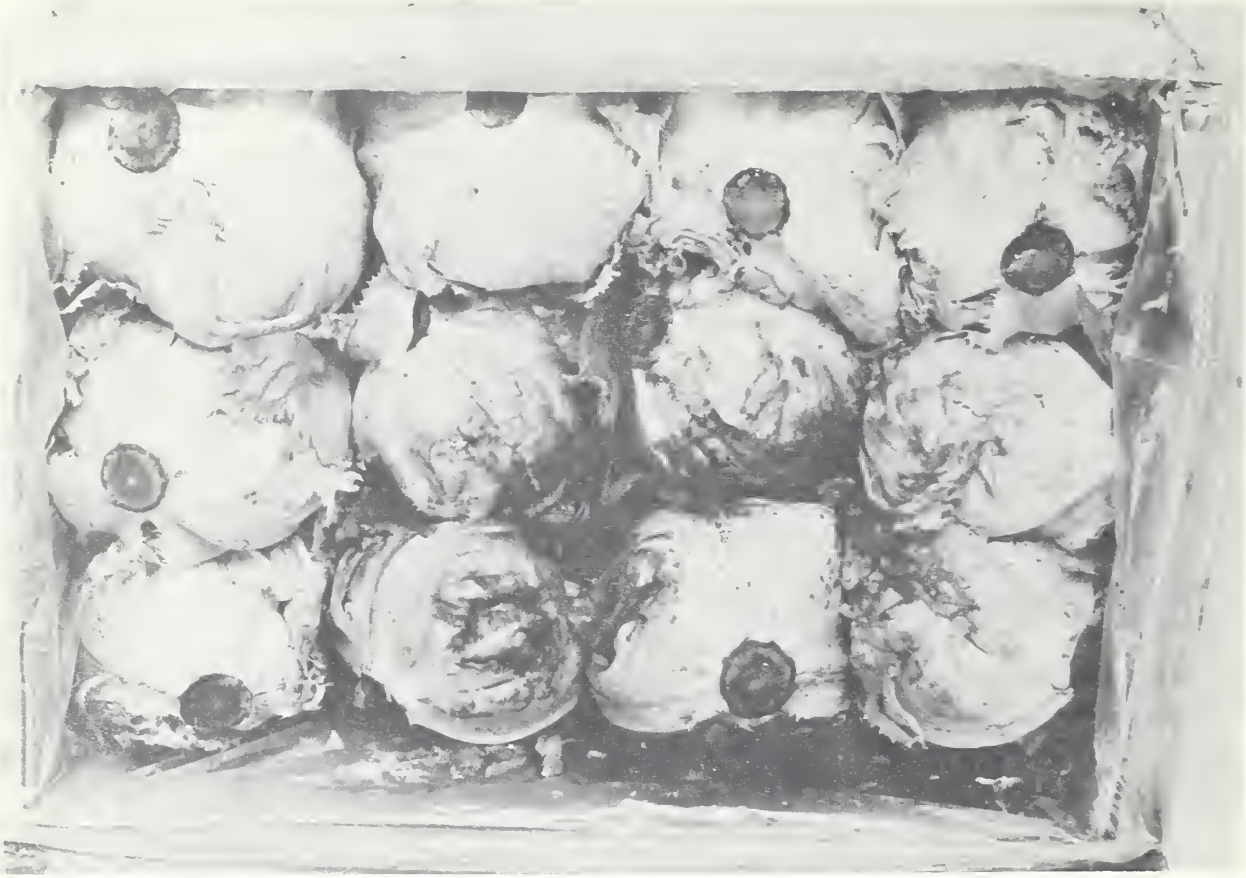

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Figure 2. --Arrival condition of lettuce in test 4, showing bacterial soft rot and russet spotting.

TABLE 5.--Russet spotting of lettuce in 3 tests in various types of packages after transit and 3 weeks at 33° or 38° F.

Trimming and packaging treatment	Number of affected leaves per head					
	Test 2		Test 3		Test 4	
	33°	38°	33°	38°	33°	38°
	No.	*No.*	*No.*	*No.*	*No.*	*No.*
Regularly trimmed, parchment-wrapped heads, in unlined crates[1]	0.6	7.1	0.2	8.2	11.1	13.5
Specially trimmed, parchment-wrapped heads, in unlined crates[1]	0.2	4.9	0.2	7.5	9.8	11.6
Regularly trimmed heads in polyethylene-lined crates	0.2	2.6	0.1	6.4	10.3	10.2
Specially trimmed heads in polyethylene-lined crates	0.8	4.2	0.5	6.2	11.1	9.6
Specially trimmed, polyethylene-bagged heads in unlined crates	0.0	2.8	0.2	4.2	7.9	8.4
Commercially trimmed heads in unlined crates[1]	0.0	7.6	0.1	6.7	13.2	13.6
Average, all treatments	0.3	4.9	0.2	6.5	10.6	11.2

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[1] Regularly trimmed, with 5-6 wrapper leaves remaining; specially trimmed, 3-4 wrapper leaves remaining; commercially trimmed, 7 or more wrapper leaves remaining.

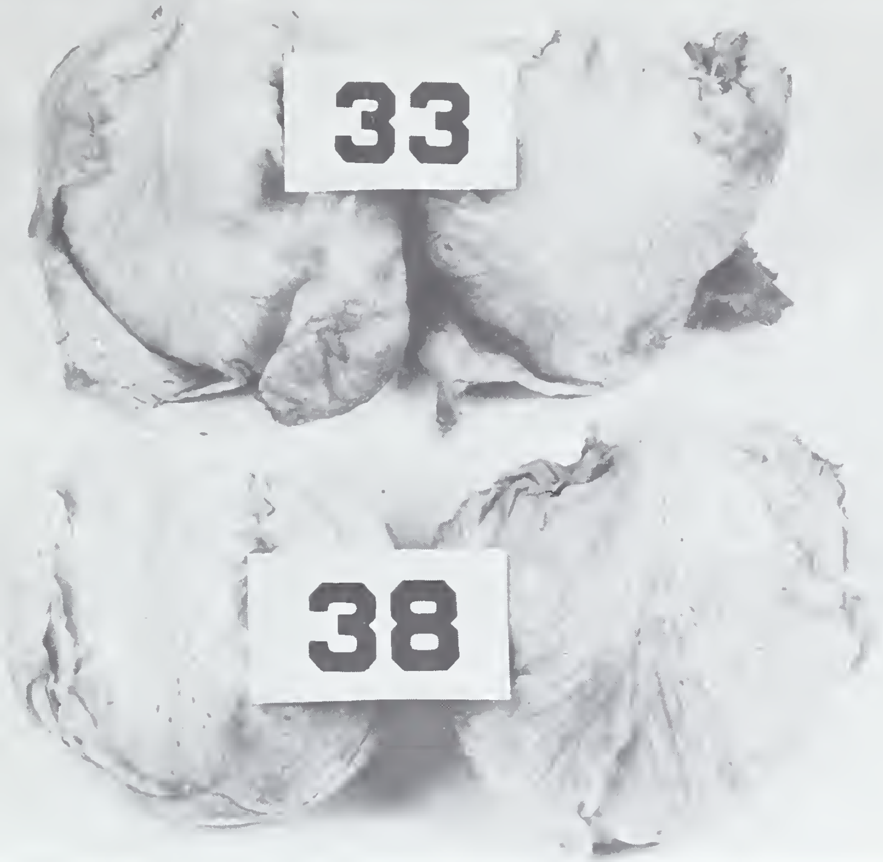

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Figure 3. --Russet spotting of lettuce after 3 weeks at 33° and 38° F. (test 3).

Shipping weight: The shipping weight of the test packages varied greatly, depending upon the amount of trimming that was done before packing. The average weight per crate of commercially trimmed heads was 48 pounds. When heads were trimmed to five or six wrapper leaves, the weight per crate was reduced to 45.5 pounds. Trimming the heads to three or four wrapper leaves reduced the weight to 40 pounds.

The benefits of trimming and packaging lettuce, are illustrated in figure 4, based on the data obtained in these tests. Figure 4 shows the number of three types of packs that would have to be stored to obtain 1,000 pounds of edible lettuce after shipment from the West Coast and 5 weeks' storage at 33° or 38° F. Note the reduced number of crates that would be required if stored at 33° rather than at 38°, or if specially trimmed heads in polyethylene bags were shipped rather than the other types of packages. Compared to the conventional Navy pack (regularly trimmed, parchment-wrapped heads in unlined crates), 15 percent more space would be required at 38° if unlined crates of commercially trimmed heads were stored. Sixteen percent less space would be required, however, if specially trimmed, polyethylene-bagged lettuce were stored at that temperature.

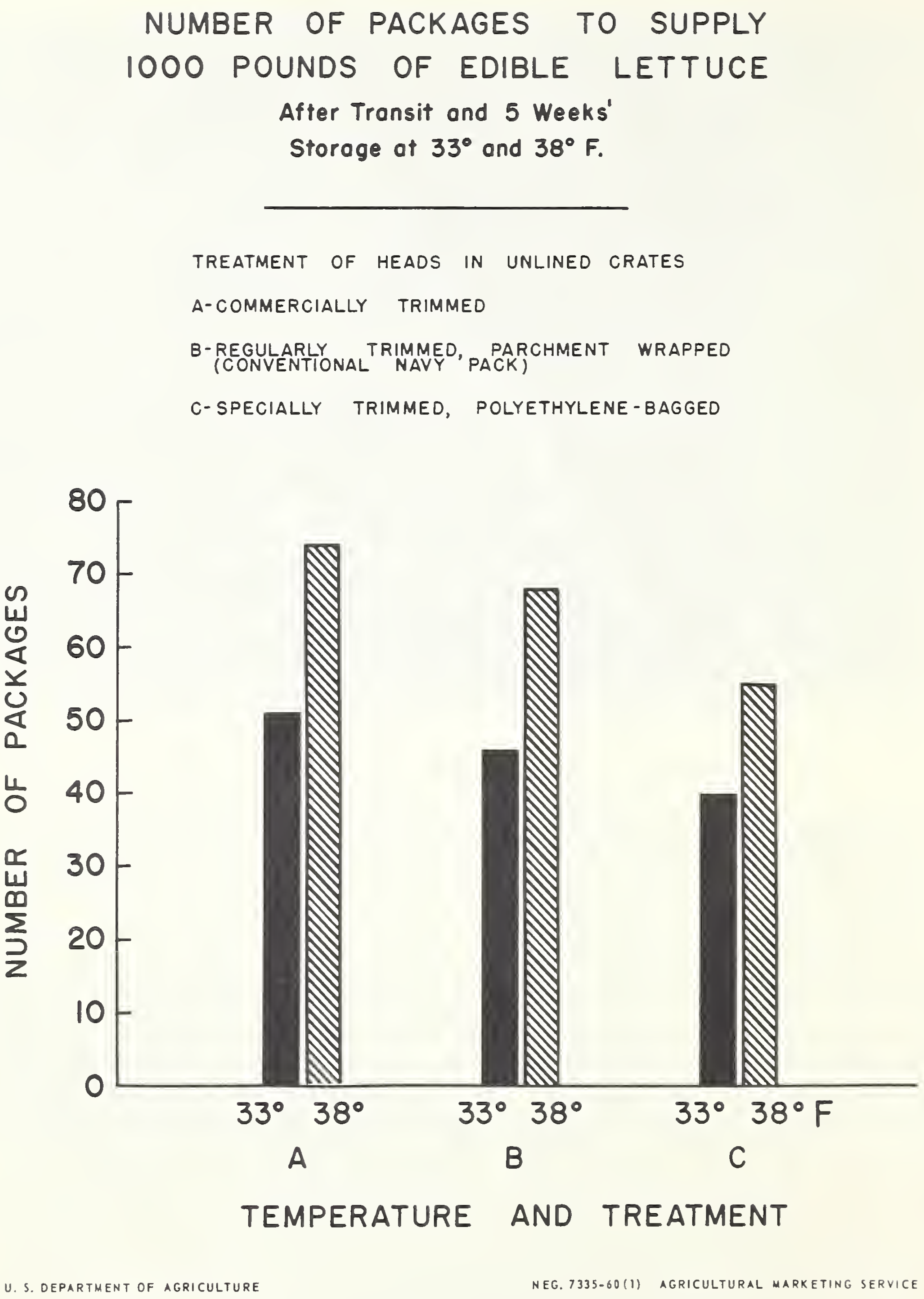
NUMBER OF PACKAGES TO SUPPLY
1000 POUNDS OF EDIBLE LETTUCE
After Transit and 5 Weeks' Storage at 33° and 38° F.
TREATMENT OF HEADS IN UNLINED CRATES
A-COMMERCIALLY TRIMMED
B-REGULARLY TRIMMED, PARCHMENT WRAPPED (CONVENTIONAL NAVY PACK)
C-SPECIALLY TRIMMED, POLYETHYLENE-BAGGED
NUMBER OF PACKAGES
80
70
60
50
40
30
20
10
0
33° 38°
A
33° 38°
B
33° 38° F
C
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Figure 4.